UTIAS SFL
Space Flight Laboratory

Building Canada's Future In Space

The CanX-2 Nanosatellite

Expanding The Science Abilities of Nanosatellites

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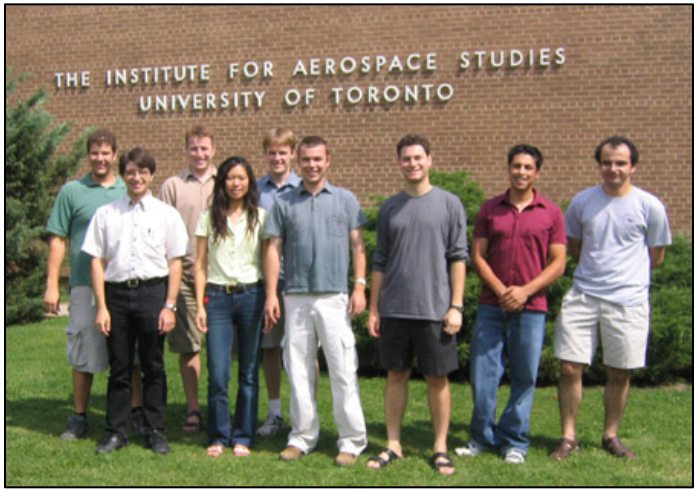
Overview

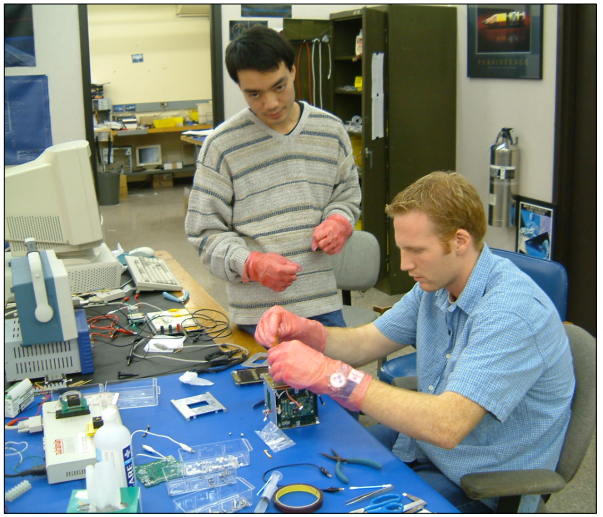
- UTIAS/SFL CanX Program
- CanX-2
  - Mission Objectives
  - Design and Specifications
- CanX-2 Payloads
- Project Status
- Applicability to AMSAT Missions



CanX-2 Student Team

CanX Program

- Student-Driven Nanosatellite Development Program
  - Satellites are designed, built, tested, and launched within a 2-year timeframe (length of M.A.Sc. degree)
  - Design requirements are also student-defined
  - Goal: research and education
- Experienced SFL staff provide mentoring and guidance to CanX team
  - Staff makes launch arrangements

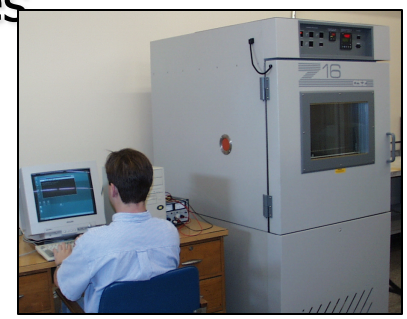


Students Assembling CanX-1

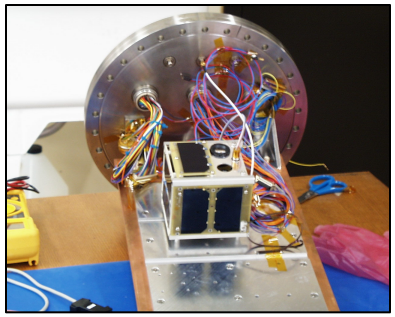
SFL Facilities

- In-house
  - Class 10,000 clean room assembly area
  - Integration phase testing equipment support
  - Two thermal chambers providing temperatures of -70 to +180°C
  - Small vacuum chamber
- Access to other U of T facilities
  - In-kind and working relationships for all aspects of satellite testing

Clean Room Facility



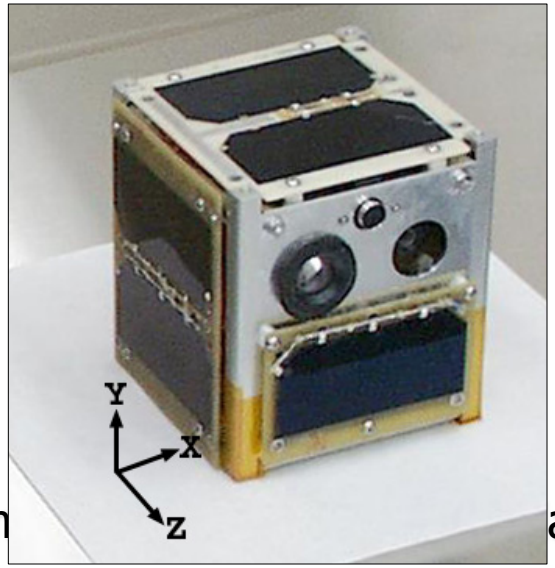
Thermal Chamber



CanX-1 Mounted for Insertion into Vacuum Chamber

Program Legacy

- CanX-1 Objectives:
  - Verify essential technologies:
    - Imaging of Earth, Moon, stars using CMOS Imagers
    - Star/horizon tracking experiments
    - Demonstration of GPS from space
    - Magnetic attitude control
    - ARM7 on-board computer (OBC)
    - Peak Power Tracking
    - Custom UHF Transceiver
  - Provide mission lifetime (one year) telem ar cells and magnetometer
- Student-led student team (with staff mentoring)
- Started in September 2001, Completed in May 2003
- Launched on June 30, 2003



CanX-1 Outcomes

- Following launch, contact was never established with CanX-1
- Despite this, 90% of our program goals have been met
  - Met challenge of building, fully testing, and launching a CubeSat in less than two years
  - Established a unique student program in Canada
  - Great student training, both in depth and breadth
  - CanX-1 is Canada's first CubeSat and smallest satellite in space

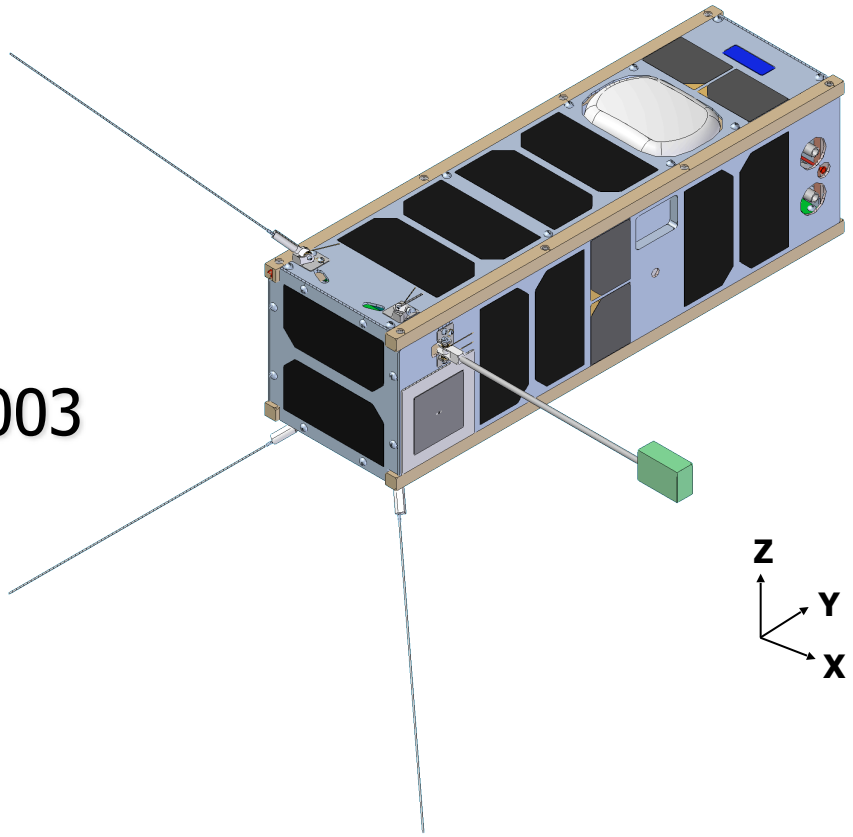
- CanX allows rapid access to space
  - Aggressive program using experimental technology
  - We understood risks of going to space so quickly
  - We pushed the envelope to learn from the experience for future missions
- Applying lessons learned from CanX-1 into CanX-2 development

CanX-2
Mission Objectives

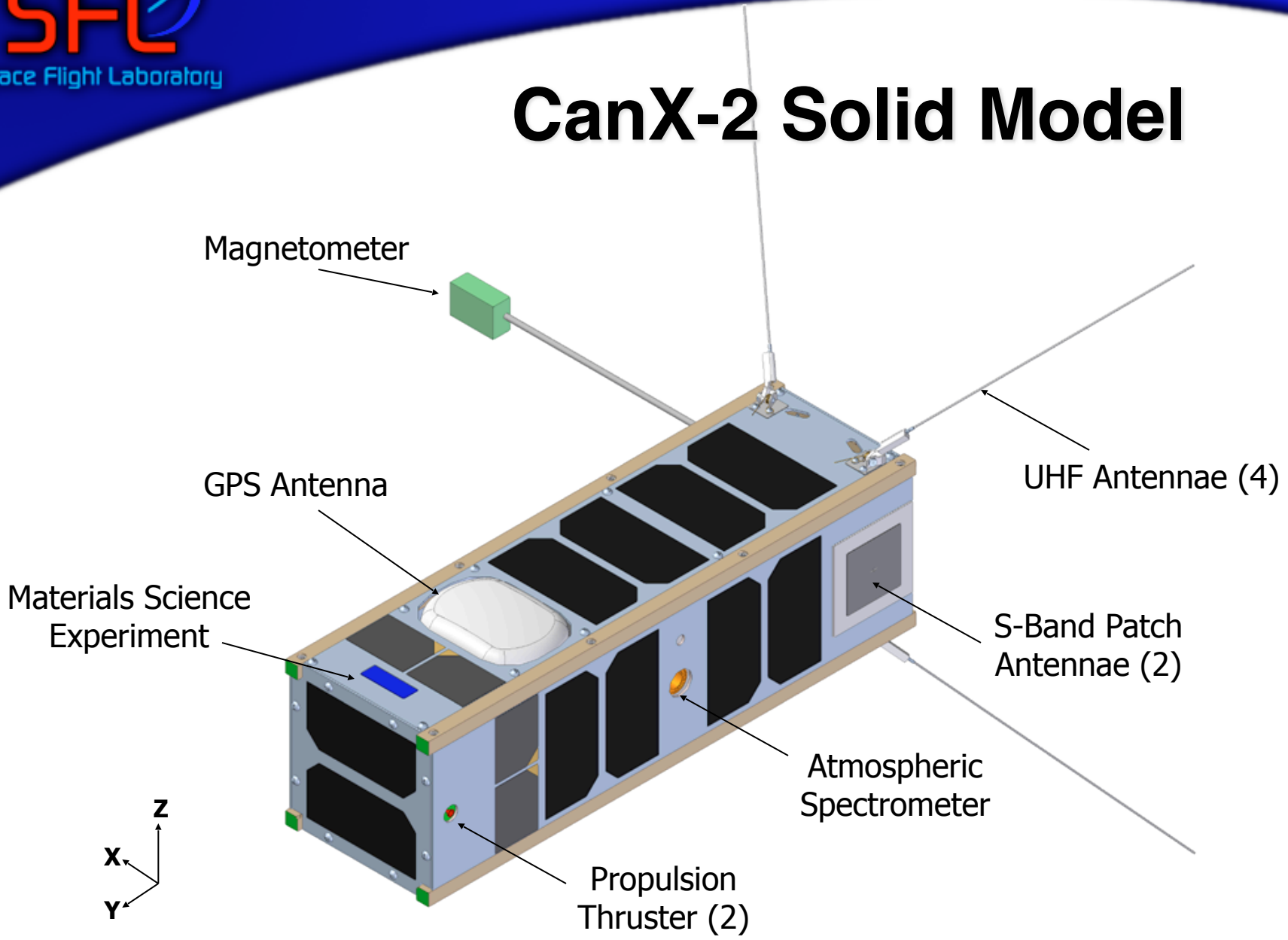
- Verify orbital operation of essential technologies:
  - ARM7 On-Board Computer
  - UHF Transceiver
- Evaluate Engineering Payloads
  - Three-axis momentum-bias attitude control system
  - Cold Gas Propulsion System
  - S-Band Transmitter
  - Two CMOS Imagers (Monochrome and Colour)
- Perform Science Experiments

CanX-2 Overview

- Triple CubeSat structure
  - 10 x 10 x 30 cm prism
  - Mass approx. 3.5 kg
  - Deployables
    - UHF Antenna Array
    - VHF Beacon Antenna
    - Magnetometer
- Project start: September 2003
- Launch target: Late 2005
- Team: 9 M.A.Sc. students, 5 SFL engineers

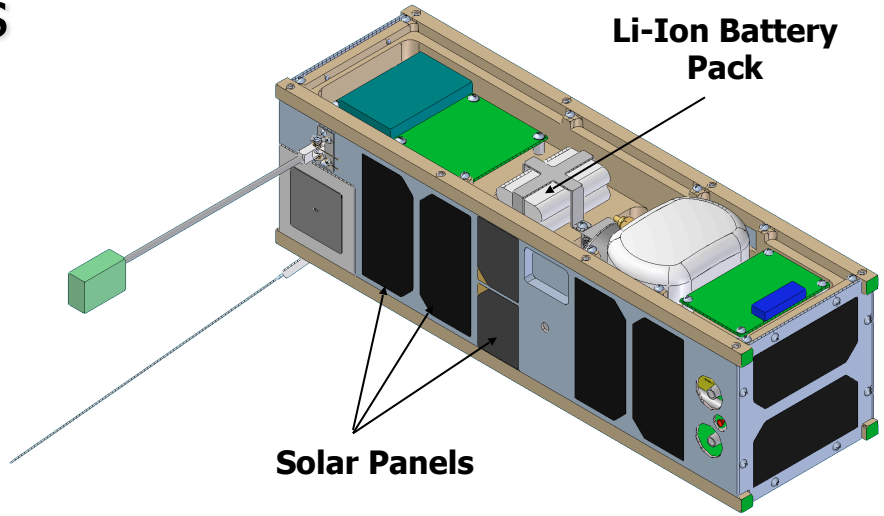


CanX-2 Solid Model

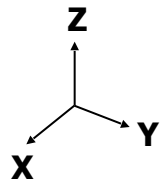


Power System

- Generated by Triple Junction GaAs solar cells
- Up to 4 W of power generated
- Energy stored by 3.6 Ah lithium-ion battery
- Distributed power regulation
- Nominal bus voltage of 3.6 V

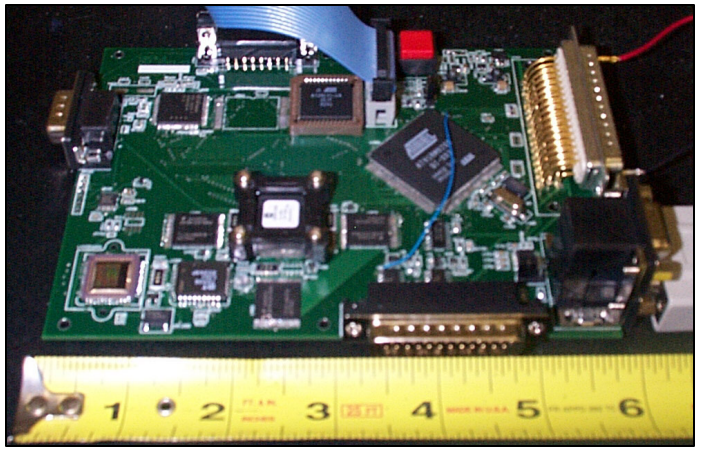


CanX-2 with +Z Panel Removed



On-Board Computer

- ARM7 based processor @ 18 MHz
  - 3 MB of EDAC-protected SRAM memory for runtime use and temporary data storage
  - 32 MB Flash for bulk data storage
  - 5 serial ports for communication with payloads
  - Very low power consumption
  - Custom pre-emptive operating system to allow multitasking with attitude control and payload management



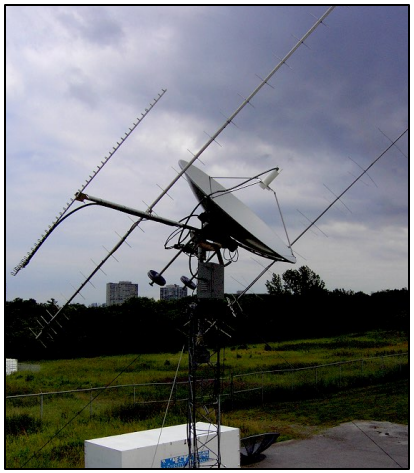
Prototype CanX-2 OBC

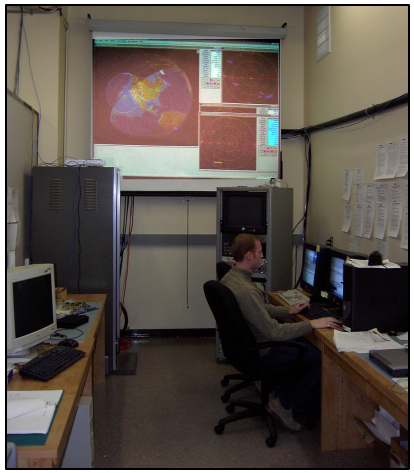
Communication System

- VHF Morse Code Beacon
  - Operating continuously after deployment in the 2 m Amateur Satellite Band
  - 15 WPM CW containing call sign and basic telemetry
    - solar panel voltage, battery voltage, temperature
  - Single quarter-wave monopole antenna
- UHF Transceiver
  - Half-duplex in the 70 cm Amateur Satellite Band
  - GFSK modulation at 4000 bit/s
  - Quad-canted turnstile antenna system fed in phase
  - Uses custom Nanosatellite Protocol (NSP), based on HDLC

Communication System

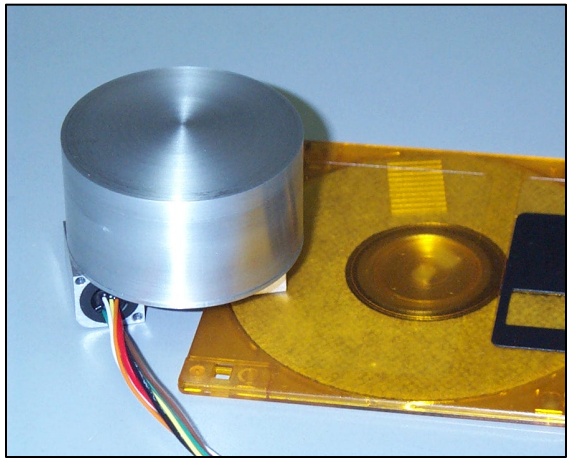
- S-Band Transmitter
  - In-house design to be space-qualified
  - Configured on build for Amateur or Space Sciences S-band frequencies
  - Feeds two RHCP patch antennae fed in phase
  - Default data rate is 32 kbps, but higher rates are possible
  - If successful, communication will be full-duplex: UHF up, S-band down
- Amateur frequencies coordinated through the IARU
- Science S-band frequency coordinated with help of Canadian Space Agency





Momentum-Bias ADCS

- Attitude Determination
  - Requirement: Estimate attitude and body rates within ±1°
  - Uses suite of Sun sensors and a 3-axis magnetometer to estimate satellite attitude via an Extended Kalman filter
- Attitude Control
  - Requirements:
    - Pointing accuracy of ±10°
    - Pointing stability of ±1°
  - Three orthogonal magnetic torquer coils
  - Momentum NanoWheel



Dynacon Momentum NanoWheel (Disk shown for scale)

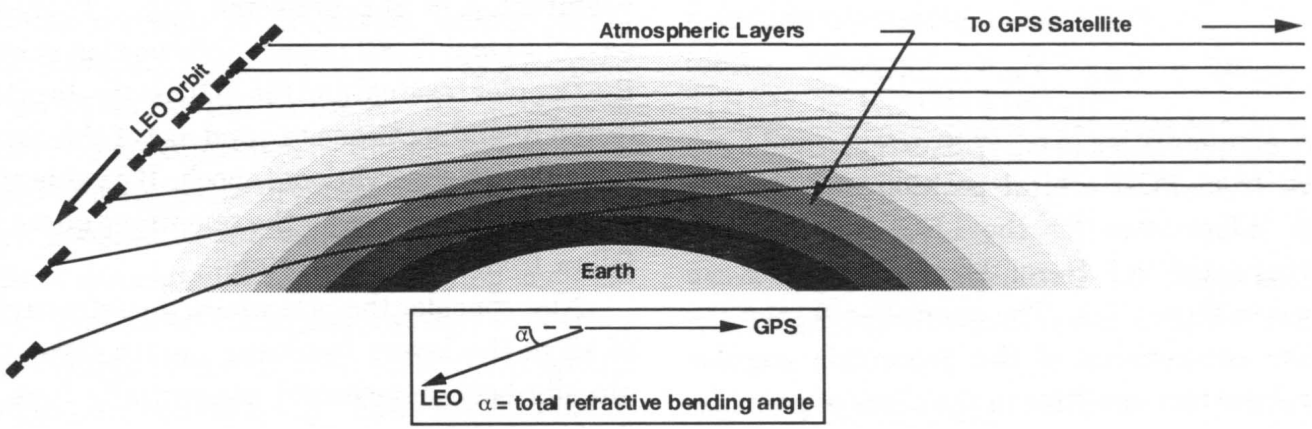
Nano-Propulsion System

- Liquid fueled cold-gas thrusters
  - Mass less than 500 g
  - Thrust expected of 50 mN
  - I_{sp} of at least 50 s
- Included to evaluate suitability for future CubeSat missions requiring station keeping capability
  - Formation flying abilities will be evaluated on CanX-4 and CanX-5 in 2007

Science Payloads

- GPS Occultation Experiment
  - S. Skone, University of Calgary
- Imaging Spectrometer
  - B. Quine, York University
- Materials Science
  - J. Kleiman, University of Toronto
- Satellite Communications Protocol
  - M. Barbeau, Carleton University

GPS Occultation



- GPS signals are tracked by a LEO Satellite
- Employ a dual-band GPS receiver
- LEO satellite records nature of GPS signals as they pass through the atmosphere during satellite occultations
  - Determine vertical-profiles of atmospheric electron density and water vapour content

Imaging Spectrometer

- Provides measurements of greenhouse gases
  - Measurements are made using Earthshine spectra
- Study global and local emissions
  - Surface resolution of 1 km
- Goals for spectrometer on CanX-2
  - Validation of hardware
  - Collection of data sets for use in computer modeling

Other Payloads

- Materials Science
  - Study the degradation of coated and uncoated samples exposed to space
  - Examination by photometric means

- Satellite Protocol
  - Evaluate the performance of a multi-satellite communication protocol
    - Self-organizing network approach

Project Status

- Most subsystems have been prototyped and tested
- Measurements made of antenna patterns

- Payload articles expected late 2004
- Structure prototype expected late 2004
- Flight hardware integration in early 2005

- Target Launch Date – Late 2005 or Early 2006

Applicability to the AMSAT Community

- CanX technology provides a platform for rapidly launching experiments into space
- AMSAT can fly payloads on CanX missions at-cost
- Possible AMSAT experiments
  - Space-qualify new transponder designs (e.g. CC-Rider)
  - Prove new technologies before use in high-cost HEO missions

- Students learn the AMSAT/Microspace philosophy
- All students that operate the satellite are licensed amateurs

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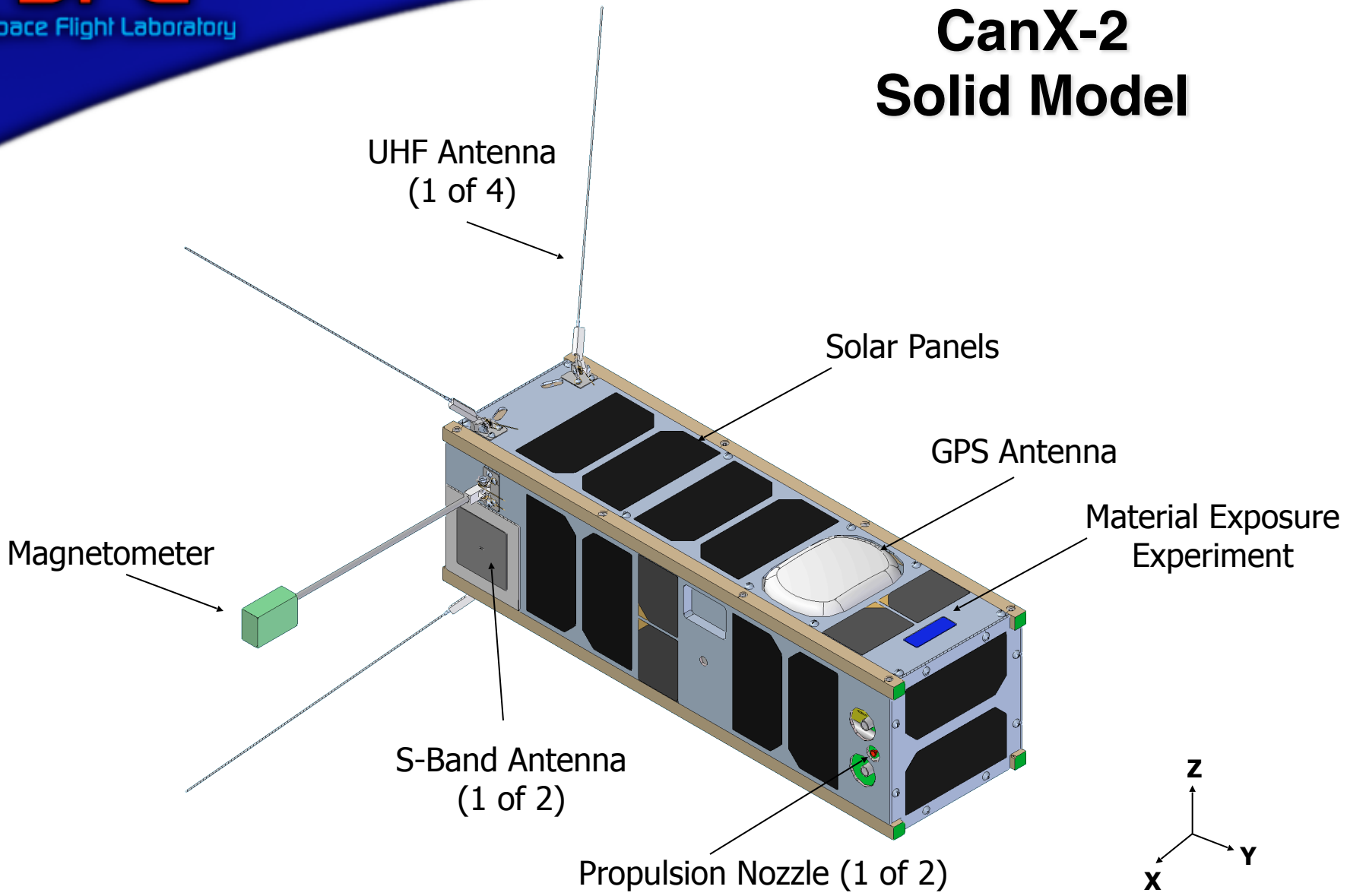
Backup Slides

CanX-2 Solid Model



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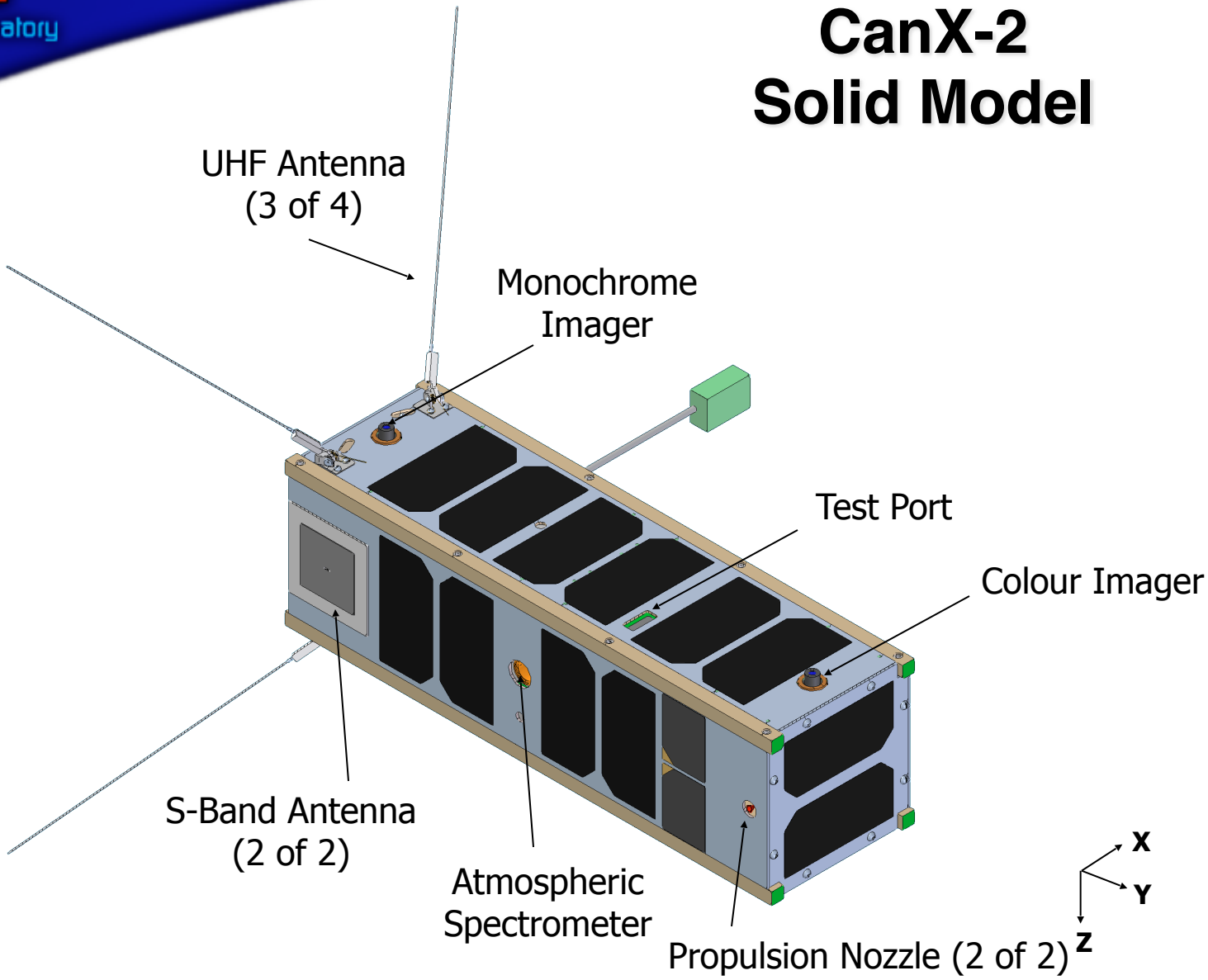

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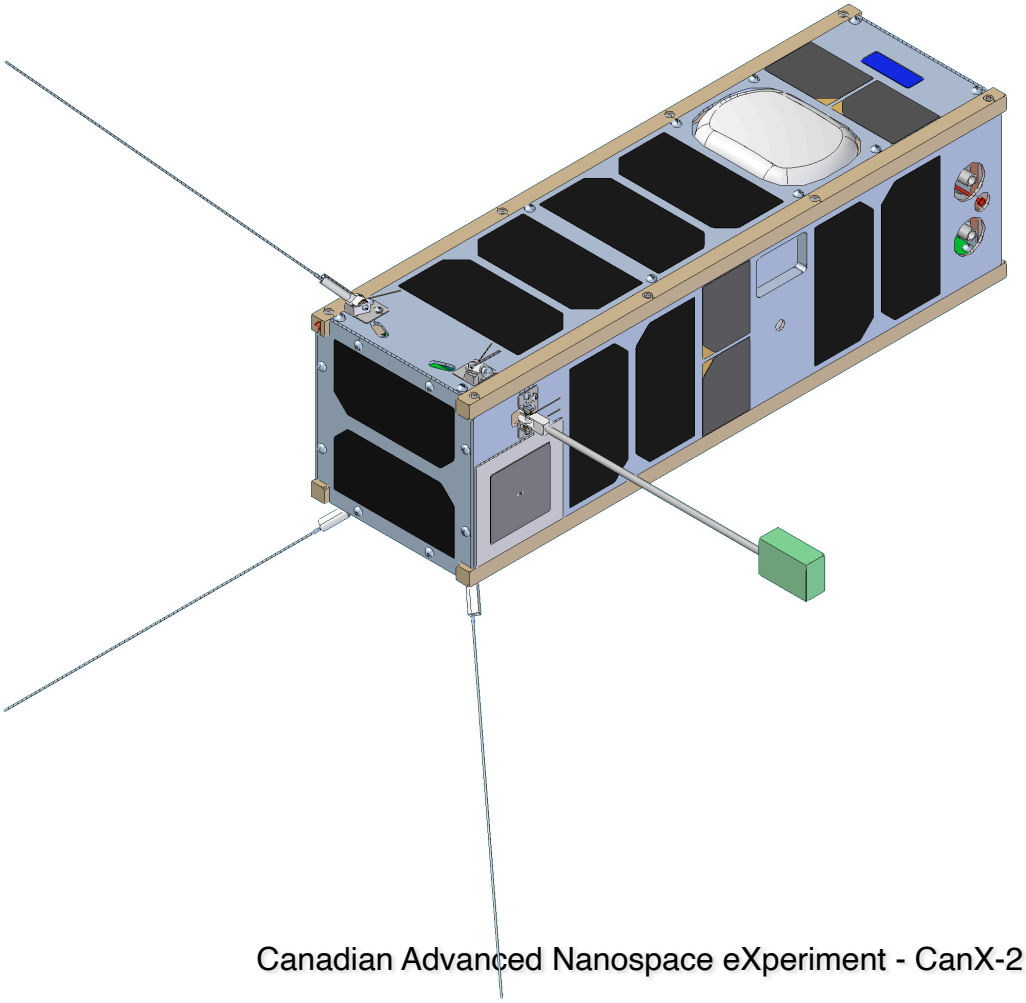

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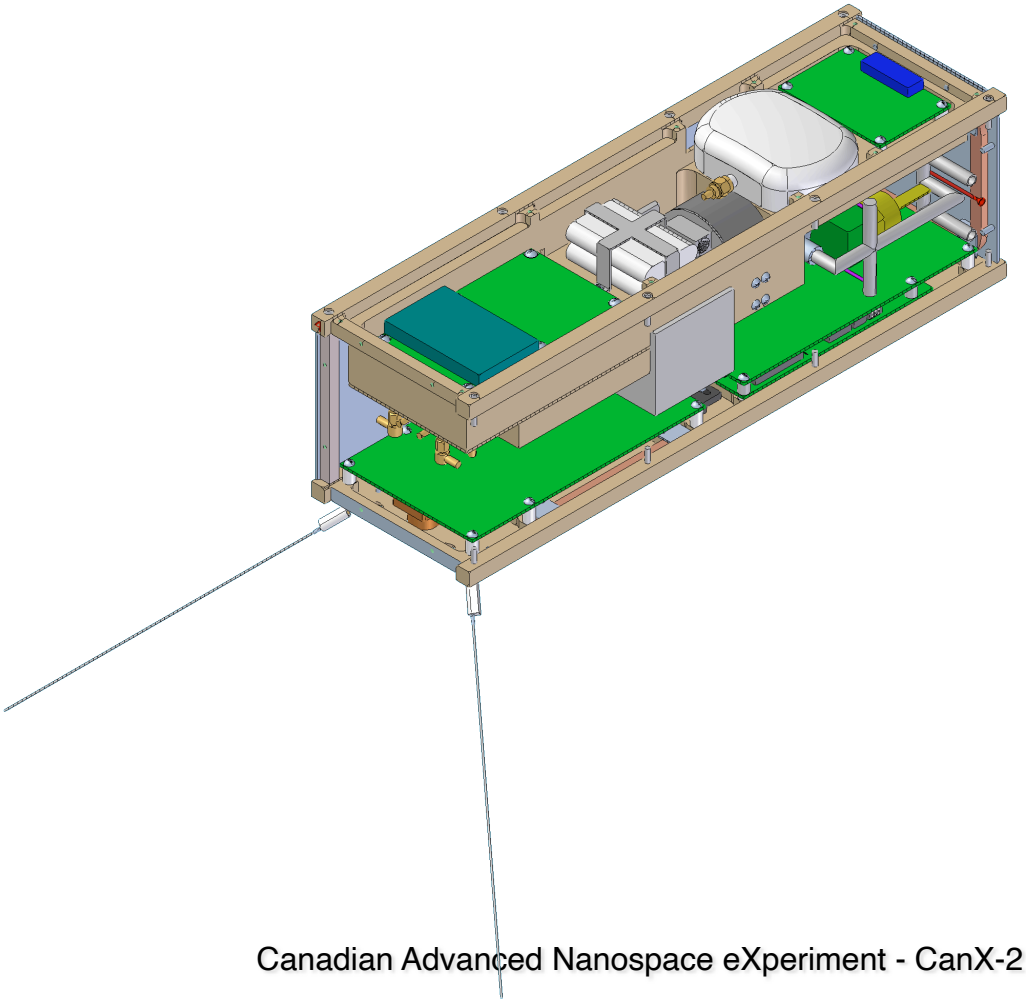


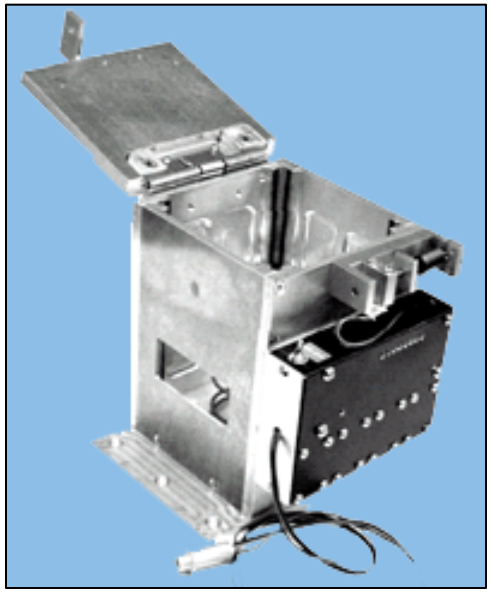
CMOS Imagers

- Colour and Monochrome
  - 1200 x 1024 resolution
  - FOV of about 30 degrees
- Used for Earth Photography
- Could be used to take pictures for ground-based star tracking experiments

Image Taken by Japanese XI-IV CubeSat

New NLS Deployer

- UTIAS/SFL have partnered with the University of Tokyo to develop an alternative CubeSat deployer: "T-POD"



- NLS T-POD will fly on SSETI Express in April 2005
- More advanced versions are under devleopment